DOCTORAL STUDIES COURSE UNIT DESCRIPTION

Name of subject	Scientific Field	Faculty	Center/Institute/ Department
Materials for Ultraviolet Photonics (8 ECTS credits)	Physics N 002	Faculty of Physics	Institute of Photonics and Nanotechnology
Student's workload	Hours	Student's workload	Hours
Lectures	16	Consultations	4
Individual study	160	Seminars	20

Course annotation
Introduction. Evolution of photonics development pf photonics devices from infrared to ultraviolet. Principles of photon generation and transmission. Requirements for materials to be used in UV photonic devices. **II-VI semiconductors.** Structure. Binary and ternary compounds, capabilities of band gap engineering. Electric and optical properties. Technologies for fabrication single crystals, epitaxial layers, and polycrystalline layers. Doping methods and problems. Heterosctructure, problems of interdiffusion. Prospects and problems in fabrication of light emitting diodes (LEDs) emitting in green and blue spectral regions. Semiconductor lasers based on ZnSe heterostructures. Light detectors based on photoresistors and photodiodes. Limitations in application of semiconductors of this group and prospects to overcome them. **Zinc oxide.** Crystal and energy structure. Growth technologies. ZnO as an "excitonic" material even at room temperature. Doping and contacts. Prospects of producing LEDs. Nanocrystals, nanorods, nanoribons, and other ZnO nanostructures. **GaN and related wide-band-gap compounds.** GaN, AlN, InGaN, AlGaN crystal and energy structure. Growth technologies; advantages and disadvantages of MOCVD, MBE techniques. Problem of substrates for epitaxial layers, lattice mismatch and differences thermal expansion coefficients. Dislocations in heteroepitaxial layers. Technologies for growing bulk GaN and AlN and problems in their application. Electrical and optical properties of nitride semiconductors. Piezoelectric properties, built-in electric fields in heterostructures, piezoelectric doping. Polar and nonpolar substrates. Mechanisms of radiative recombination. Polarization of emitted light. Problems in growing high-Al-content AlGaN. Doping, oxygen contamination, structural defects. Heterostructures and their application in production of UV LEDs. Solar-blind AlGaN photodiodes. Quaternary compound AlInGaN. Band gap and lattice engineering. Deposition peculiarities. Prospects for application. **Indirect bad gap materials.** Silicon carbide, its polytypes. Evolution of SiC electroluminescence and prospect for its applications. Diamond. Fabrication technologies for single-crystal and polycrystalline diamond. Diamond applications in technologies and prospects for applications in photonics. **Materials for passive optical elements in UV region**. Quartz, fused quartz. Fluorides of sodium, magnesium and barium.

List of literature			
1. J. Li et al., III-Nitrides Light Emitting Diodes: Technology and Applications, Springer (2020). 2. Advancing Silicon Carbide Electronics Technology II: Core Technologies of Silicon Carbide Device Processing, K. Zekentes and K. Vasilevskiy (Editors), Materials Research Forum LLC (2020). 3. Ching-Hua Su, Vapor Crystal Growth and Characterization: ZnSe and Related II–VI Compound Semiconductors, Springer (2020).			
Consulting teachers	Scientific degree	Pedagogical name	Main scientific works published in a scientific field in last 5 year period
Gintautas Tamulaitis	habil. Dr.	Prof.	1. K. Nomeika, Ž. Podlipskas, M. Nikitina, S. Nargelas, G. Tamulaitis, R. Aleksiejunas, Impact of carrier diffusion on the internal quantum efficiency of InGaN quantum well structures, J. Materials Chemistry C, 10, 1735-1745 (2022). 2. D. Dobrovolskas, A. Kadys, A. Usikov, T. Malinauskas, K. Badokas, I. Ignatjev, S. Lebedev, A. Lebedev, Y. Makarov and G. Tamulaitis, Luminescence of structured InN deposited on graphene interlayer, J. Lumin. 232, 117878 (2021). 3. O. Kravcov, J. Mickevičius, G. Tamulaitis, Kinetic Monte Carlo simulations of the dynamics of a coupled system of free and localized carriers in AlGaN, Journal of Physics: Condensed Matter 32, 14 (2020). 4. M. Korzhik, G. Tamulaitis, A. Vasil'ev, Physics of Fast Processes in Scintillators, Springer, 262 pages, (2020). 5. T. Ceponis, K. Badokas, L. Deveikis, J. Pavlov, V. Rumbauskas, V. Kovalevskij, S. Stanionyte, G. Tamulaitis, E. Gaubas, Evolution of Scintillation and Electrical Characteristics of AlGaN Double-Response Sensors During Proton Irradiation, Sensors, 19, 3388 (2019).
Jūras Mickevičius	Dr.		1. K. Badokas et al., MOVPE Growth of GaN via Graphene Layers on GaN/Sapphire Templates, Nanomaterials, 12, 785 (2022). 2. O. Kravcov, J. Mickevičius, G. Tamulaitis, Kinetic Monte Carlo simulations of the dynamics of a coupled system of free and localized carriers in AlGaN, Journal of Physics: Condensed Matter 32, 14 (2020). 3. M. Dmukauskas, J. Mickevičius, D. Dobrovolskas, A. Kadys, S. Nargelas, G. Tamulaitis, Correlation between growth interruption and indium segregation in InGaN MQWs, Journal of Luminescence 221, 117103 (2020). 4. J.Mickevičius, M.Andrulevicius, O.Ligor, A.Kadys, R.Tomašiūnas, G.Tamulaitis, and E.-

			M.Pavelescu, Type-II band alignment of low-boron-content BGaN/GaN heterostructures, Journal of Physics D: Applied Physics 52, 325105 (2019). 5. J.Mickevičius, M.Andrulevicius, O.Ligor, A.Kadys, R.Tomašiūnas, G.Tamulaitis, and E.-M.Pavelescu, Type-II band alignment of low-boron-content BGaN/GaN heterostructures, Journal of Physics D: Applied Physics 52, 325105 (2019).
Certified at Doctoral Committee session of 02/02/2022, protocol No. (7.17 E) 15600-KT-32			
Committee Chairman: Prof. S. Juršėnas			